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Assessing the relationships between human capital, innovation and technology adoption: Evidence from sub-Saharan Africa

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ABSTRACT

In spite of growing body of research on human capital and innovation, our understanding of the effects and roles of human capital in enhancing innovation and technology adoption in the developing world particularly sub-Saharan Africa remains limited. Using a sample of 45 sub-Saharan African countries from 1960 and 2010, we measure innovation and technology adoption using the Malmquist productivity index approach, and examine the effects of human capital on innovation and technology adoption using different panel data techniques. The study uncovers that the overall mean estimates over the period shows a decline of 0.08% for innovation and a moderate increase of 1.7% for the adoption of technology. Indeed, many countries in the sample experienced technical regress or decline in innovation, but the estimates for most countries showed an improvement in adoption of technology. Human capital appears to exert a positive and statistically significant impact on adoption of technology whilst, its effect on innovation is found to be insignificant.

1. Introduction

For decades, scholars across the social sciences have uncovered human capital as the engine of productivity and growth of nations through innovation and adoption of technology (Nelson and Phelps, 1966; Romer, 1990a; Aghion and Howitt, 1992). It has been suggested that the stock of human capital enhances a country's ability to develop local technological innovation and dissemination of knowledge (World Development Report, 1998). Many contemporary technology and management authors have stressed the importance of new technology adoption in fostering innovation (see Lanzolla and Suarez, 2012; Galang, 2012) as well as facilitating the technology catch-up in the 21st century (Lee, 2013; Zhang and Zhou, 2016). The existing body of research on the relationship between human capital and innovation has concentrated mainly on developed economies where there is a more stable and well-developed institutional environment. Accordingly, it remains unclear whether these findings will hold in an institutional environment of developing economies, where the “rules of the game” are often uncertain (North, 1990; Radjou et al., 2012; George et al., 2012).

Despite these important streams of research, our understanding of how human capital enhances innovations and technology adoption in developing countries remains limited. The primary objective of this study is to examine the effects of human capital in enhancing innovation and technology adoption in developing countries. We focus specifically on sub-Saharan Africa as an empirical setting. Indeed, sub-Saharan Africa represents a promising avenue to shed light on effects of human capital on innovation and adoption of technology (Amankwah-Amoah, 2016b). We use the Malmquist productivity index approach to compute innovation (technical change) and adoption of technology (efficiency change) for 45 sub-Saharan Africa countries. Then using various panel data techniques we empirically explore the role played by human capital on innovation and adoption of technology.

This study offers several contributions to human capital and innovation literature. First, we deviate from much of the existing literature on the relationship between human capital and innovation that has focused on mainly single country (see Dakhli and De Clercq, 2004) by employing data for 45 SSA countries to deepen our understanding of the subject. Thus, we add to the new growing body of scholarly works exploring how governments' STI policy can be formulated to generate economic development and aid poverty reduction efforts in the developing world (Amankwah-Amoah, 2016a; Clark and Frost, 2016; Kaplinsky et al., 2009). In addition, our study contributes to the literature on technology adoption (Lanzolla and Suarez, 2012), human capital theory (Becker, 1964; Schultz, 1961) and innovation (Etzkowitz and Leydesdorff, 2000) by deepening our understanding of the role of human capital in enhancing innovation and facilitating

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technology adoption in SSA. Moreover, the study adds further evidence to the growing streams of research that have shown that the quality of human capital, ability to develop, leverage and utilise might be the most important factors in explaining the effects of human capital on technological achievement rather than the mere possession of human capital by a nation or firm (see Sirmon et al., 2007, 2011).

The remainder of the paper is organized as follows. In the next section, we present a review of the literature on the relationship between human capital, innovation and adoption of technology. We turn our attention to the method adopted and data sources. This is then followed by the results and their interpretations. The final section sets out theoretical and practical implications.

2. Background literature

The general human capital theory (Becker, 1964) provides a theoretical underpinning towards a better understanding of the role of individuals in enhancing innovation and adoption of technology. Human capital theory is about the role of human capital in the production process and the incentives to invest in skills, including pre–labour market investments (in the form of schooling) and on-the-job investments (in the form of training). Human capital refers to an individual's knowledge, skills and experiences, which can be utilised to foster innovation activity (Becker, 1964; Schultz, 1961). For the purposes of this study, however, the key aspect of human capital has to do with the knowledge and skills embodied in people and accumulated through schooling, i.e., educational attainment that is useful in the production of goods, services and further knowledge.

Human capital has an important effect on productivity growth because of its role as a determinant of an economy's capacity to carry out technological innovation (Romer, 1990a) and, for developing countries in particular, to adopt (and adapt and implement) foreign technology. The new wave of the endogenous growth literature (which is connected to the work by Nelson and Phelps, 1966) highlights the role of human capital in promoting productivity growth indirectly through the facilitation of domestic innovation, and diffusion and adoption of new technologies (see Romer, 1990b; Grossman and Helpman, 1990, 1991; Aghion and Howitt, 1992; Aghion et al., 1998). In the form of level of education, one may want to distinguish between basic education and higher education. The former is important for learning-capacity and utilising information, while the latter is necessary for technological innovation. The more education the easier it is to master new technologies (Easterlin, 1981).

As yet there are a very few empirical literature testing the importance of human capital for innovation and adoption of technology. These studies are mostly focused on the developed OECD countries (see Benhabib and Spiegel, 2005; Barro and Sala-I-Martin, 1997; Barro, 1991; Vandenbussche et al., 2006) with only a few studies on developing countries (Ang et al., 2011; Danquah and Ouattara, 2014). The empirical evidence largely demonstrates that the stock of human capital not only enhances the ability of a country to develop its own technological innovation, but also increases its capacity to adopt the already existed knowledge elsewhere and thereby facilitates increase productivity and economic growth. For instance, Benhabib and Spiegel (2005) using a panel dataset covering 19 OECD countries between 1960 and 2000 found that the growth-enhancing margin in OECD countries is that of skilled human capital (tertiary educational attainment) rather than that of total human capital. Benhabib and Spiegel (2005) also estimated the threshold level of human capital needed to exert positive effect on innovation and suggest that countries with sufficiently small human capital stock or low levels of educational attainment may experience slower innovation as compared to the technologically leading nations. Focusing attention on the composition of human capital, Vandenbussche et al. (2006) surmise that the tasks of technology adoption and innovation require different types of human capital. In particular, they assume that unskilled human capital is better suited to technology adoption than to innovation. Their findings on OECD countries show that the growth enhancing properties of human capital to productivity growth depends on its composition. Also, the growth-enhancing margin of innovation in OECD countries is that of skilled human capital (tertiary educational attainment) rather than that of total human capital. The higher growth enhancing effect may be due to the assumption that innovation is a relatively more skill-intensive activity than adoption of technology.

Using a sample of developed and developing countries, Ang et al. (2011) show that, the growth enhancing effects of tertiary education attainment or skilled human capital promotes innovation only in high income countries, thereby supporting the findings of the studies in OECD countries. On the other hand, Ang et al. (2011) also found that tertiary education attainment does not contribute to innovation and growth, and have no growth enhancing effect in low income countries. Using data from SSA countries, Danquah and Ouattara (2014) similarly found that human capital does not exert statistically significant effect on productivity growth. Danquah and Ouattara (2014) attribute the inconsequential contribution of human capital to the negligible growth enhancing effects of human capital as SSA countries move closer to the world technology frontier.

Past studies have also indicated that human capital relates to firms' ability to develop and maintain their competitiveness (Youndt et al., 2004; Ployhart and Moliterno, 2011; Ployhart et al., 2011). Firms' ability to develop business ideas and innovation has been found to be predicated on the quality of human capital held by the employees (Deakins and Whittam, 2000). Similarly, governments' ability to initiate policy and ensure effective implementation is also grounded on quality of human capital within its agencies and enterprises (Amankwah-Amoah, 2016a; Amankwah-Amoah and Sarpong, 2016). It is argued that quality of human capital within the wider society would foster innovation and new technology adoption.

Government-sponsored training courses have been found to be particularly effective in encouraging individuals to upgrade their skills (World Development Report, 2008). By investing scarce national resources in training and information campaigns, government can create conditions for knowledge about new technology for diffusion (World Development Report, 2008).

A number of studies have indicated that it is not the mere possession of human capital that delivers these benefits rather the ability to deploy and utilise them that create conditions for innovation and new business development (see Carmeli, 2004; Amankwah-Amoah, 2015). Notwithstanding these insights, the effects of human capital in enhancing innovation and technology adoption warrants further scholarly attention. Based on the theoretical and empirical discussions on the role of human capita above, we expect the sign of the estimated coefficient of human capital to be positive across innovation and adoption of technology in sub-Saharan Africa.

2.1. Total factor productivity

Empirical literature on economic growth investigating the proximate causes of the enormous differences in per capita income across countries usually indicate that these differences in incomes are largely a consequence of differences in Total Factor Productivity (TFP) growth (see Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999; Easterly and Levine, 2001; Jerzmanowski, 2007; Danquah and Ouattara, 2015). Explained in the context of production possibilities frontier, TFP growth can be decomposed into two mutually exclusive and exhaustive components; innovation (technical change) and adoption of technology (efficiency change) (see Färe et al., 1994; Lovell, 1996; Kumbhakar and Wang, 2005). Some of the important studies in this specific research context of Sub Saharan Africa indicate a more prominent role to total factor productivity (i.e., innovation and adoption of technology) in explaining its relatively slow growth over the last four decades (see Collins and Bosworth, 2003). Devarajan et al. (2003) argue strongly